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(54) **Apparatus for removing bubbles from a liquid.**

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FR-A-2 452 936
US-A-3 849 071
US-A-4 368 118

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Description

The present invention relates to an apparatus as defined in the introductory portion of claim 1 for removing bubbles from a liquid having a medical use.

More particularly, the invention is concerned with an apparatus for removing bubbles from a liquid such as blood flowing in an extracorporeal blood circuit of artificial organs, e.g., an artificial lung, artificial kidney, separator for separating blood plasma from blood cells, and so forth, and the dialysate which flows in a dialysis circuit in an artificial kidney.

There are three types of apparatus for removing bubbles from a liquid. These are an apparatus of filtration type, an apparatus of settling type, and an apparatus which makes combined use of both the filtration type and settling type.

The apparatus of filtration type usually employs a filter having a pore size of 20 to 45 micrometre or a screen having a mesh size of 180 to 200 micrometres. The filter, however, produces a large pressure loss and tends to damage the constituents of blood, while the screen often fails, inconveniently, to trap minute bubbles.

In the apparatus of the settling type, as well as the apparatus which simultaneously uses both the filtration type and settling type, a blood reservoir of a large volume is employed, in which the blood is temporarily stored to allow the bubbles to be separated by buoyancy. In such apparatus, it is possible to remove fine bubbles to some extent, provided that the volume of the reservoir is sufficiently large. The large reservoir volume, however, increases the quantity of blood for priming, i.e., for filling up the reservoir. Consequently, the quantity of blood or other similar liquid for transfusion, as well as the quantity of residual blood or liquid after circulation, is increased. This results in various troubles.

Under these circumstances, the present inventor has already proposed, in the specification of Japanese Provisional Patent Publication No. 58—163372 published after the Priority Date of the application, an apparatus for use in a blood circuit which is capable of removing even fine bubbles from the blood, while diminishing the quantity of blood required for priming and minimizing the pressure loss caused by the filter. More specifically, this proposed apparatus has, as shown in Figure 1, a vessel 2, a planar filtration member 3 disposed in the vessel 2 so as to divide the space in the vessel 2 into an upper space and a lower space, a liquid inlet port 4 provided in the wall of the vessel 2 for communication with the upper space and adapted to introduce the liquid into the upper space in the form of a vortex flow around the axis of the vessel 2, a liquid outlet port 5 provided in the wall of the vessel 2 for communication with the lower space in the vessel 2 and adapted to allow the treated blood passed through the filtration member 3 to be discharged therethrough, and a gas outlet port 6 provided in the wall of the vessel 2 for communication with the uppermost region of the upper space in the vessel 2 and adapted to allow the separated gas to be discharged therethrough. With this apparatus 1, therefore, the bubbles in the blood are positively separated centrifugally in the outer peripheral region where the velocity of vortex flow is high, while in the central region where the flow velocity is small, the centrifugally separated bubbles are allowed to float so as to be discharged through the gas outlet port. Consequently, it is possible to efficiently remove the bubbles with reduced quantity of liquid for priming.

This apparatus 1, however, suffers from the following disadvantage. Namely, the filtration member 3 having a planar shape offers substantial resistance to the blood flowing therethrough causing problems such as a pressure loss and damage to the blood. To avoid these problems, the filtration member 3 is required to have a diameter, i.e., filtration area, large enough to suppress the pressure loss and the damage to blood. Consequently, the volume of the vessel 2 is increased to require a certain quantity of blood for priming. Thus, there is still a demand for reduction of the quantity of blood for priming.

US—A—4 368 118 describes a blood air separator and filter comprising a generally cylindrical vessel and a filtration member disposed in said vessel. The filtration member divides the inner space of said vessel into an inlet space and an outlet space. The vessel is provided with an inlet port which is in combination with the inlet space and which is adapted to introduce a liquid into the vessel in the form of a vortex. Furthermore, the vessel is provided with a liquid outlet port for discharging the liquid after passing the filtration member. Furthermore, a gas outlet port is provided at the upper-most region of said liquid inlet space for discharging separated gas.

The above-described apparatus suffers by the drawback that it is not failsafe in operation since the vortex itself is not adapted to separate fine bubbles from the liquid, especially when a higher discharge velocity is required. A further drawback arises in the resistance of the filtration member so that a pressure drop cannot be avoided by using said apparatus.

US—A—3 849 071 describes a filter, which is of a cylindrical shape and which is arranged coaxially within the interior of the housing of the separator. Furthermore, said filter is also provided with an upper-most filtering wall adjacent to the liquid inlet port.

The apparatus for removing bubbles from liquid, to which the invention pertains, is used not only in the blood circuit but also in the dialysis liquid circuit of an artificial kidney for removing bubbles from the dialysis liquid. Removal of bubbles from the dialysis liquid is necessary because bubbles attaching to the dialysis membrane (wall of hollow fibers) for a dead space, thus lowering the dialysis efficiency, and may enter the human body through any defects in the wall of the hollow fiber.

The object underlying the present invention is to provide an apparatus of the above-described type which is simple in construction, failsafe in operation and which is capable of satisfactorily removing even fine bubbles from a liquid while reducing the pressure loss caused by the filtration member and diminishing the priming volume.

According to the present invention, said object is solved in that said filtration member is of an essentially conical shape and disposed in said vessel coaxially therewith, an upper apex end of said filtration member being positioned at substantially the level of said liquid inlet port, and the filtration area of said filtration member being reduced in the vicinity of its upper end and increasing in the axial direction toward the bottom end of said filtration member in accordance with its conical configuration.

According to a preferred embodiment of the invention, the filtration member is made of a porous material having a pore size ranging between 50 and 260 micrometres.

According to another preferred embodiment of the invention, the filtration member is made of a hydrophilic material.

According to another preferred embodiment of the invention, the filtration member is made of a porous material treated beforehand to become hydrophilic.

According to another preferred embodiment of the invention, a pillar is provided in the three dimensional filtration member for reducing the volume thereof.

According to a further preferred embodiment of the invention, the filtration member of substantially conical shape is provided at its upper end with a communication port which provides a communication between the fluid inlet space and the fluid outlet space.

According to still further preferred embodiment of the invention, the filtration member of substantially conical shape is provided over its upper end with eddy-current blocking plate which prevents eddy currents of bubbles formed thereon from entering the liquid outlet space.

The above objects, features and advantages of the invention will become clear from the following description of the preferred embodiments when the same is read in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the drawings thereof.

Brief description of the drawings

Figure 1 is a front elevational view of a conventional apparatus for removing bubbles from a liquid;

Figure 2 is a circuit diagram of an artificial lung;

Figure 3 is a partly-sectioned front elevational view of an embodiment of the apparatus in accordance with the invention;

Figure 4 is a sectional view of a filtration member incorporated in the apparatus of the invention;

Figure 5 is a sectional view of a modification of the filtration member;

Figure 6 is a front elevational view of a practical example of the apparatus of the invention for removing bubbles from a liquid.

Figure 7 is a front elevational view illustrating the details of the apparatus shown in Figure 6; and

Figure 8 is a sectional view taken along line X—X in Figure 7.

Figure 3 shows an apparatus 20 for removing bubbles from blood, constructed in accordance with the invention. The apparatus 20 has a vessel 21, an upper space 22 serving as the liquid inlet space, lower space 23 serving as the liquid outlet space, filtration member 24, liquid inlet port 25, liquid outlet port 26, gas outlet port 27 and a valve 28.

This apparatus 20 is characterised by the fact that the filtration member 24 which is substantially shaped in a cone with its entire conical surface constituted by a mesh screen. More specifically, as shown in Figure 4, the conical filtration member 24 is constituted by a conical carrier 29 made of polypropylene and a mesh of polyester fiber having a pore size of 160 micrometers, formed as a unit with the carrier 29 by an insertion molding. The mesh 30 may be made of a material other than polyester fiber, e.g., fibers of polyamide, polytetrafluoride, polyethylene and so forth. Among these materials, fibers of polyester and polyamide are preferably used because these fibers exhibit only a slight tendency for bubbles to become attached thereto. It is also preferred that the mesh represents hydrophilic characteristic. So as to meet this demand, it is necessary that the mesh is made of hydrophilic material or made of a material treated beforehand to become hydrophilic. The hydrophilic mesh will easily be wetted by the liquid to prevent the bubbles from becoming attached thereto. The treatment for rendering the mesh hydrophilic can be attained by application of a plasma or by coating with a hydrophilic material such as polyvinylpyrrolidone, polyvinylalcohol, albumin or the like protein, and hydrophilic silicone. A port 31 is formed in the upper end of the conical filtration member 24 so as to provide communication between the upper space 22 and the lower space 23.

The communication port 31 produces a remarkable effect in removing bubbles during priming. Namely, when the mesh of the filtration member 24 is wetted by the blood during priming, a liquid film, i.e., a blood film, is formed on the mesh. Consequently, the air in the filtration member is trapped by and confined in the film on the mesh. The air, however, can be expelled as the blood level is raised and is discharged into the liquid inlet space through the communication port 31 and is perfectly purged through the gas outlet port 17.

The operation and the advantages of the embodiment are as follows. Namely, in the apparatus 20 of the embodiment, since the filtration member 24 has a conical form, an ample volume of the upper space 22 is preserved to permit effective separation of bubbles from the blood by centrifugal force. The conical filtration member 24 offers another advantage in that it

never impedes the upward flow of the separated bubbles in the central zone of the upper space 22. For these reasons, it is possible to reduce further the outside diameter of the vessel and, hence, the quantity of the priming liquid.

The communication port 31 formed in the upper end of the filtration member 24 offers the following advantage. Namely, when residual gas bubbles are found in the lower space below the filtration member 24 after the start of the circulation, the vessel 21 is lightly vibrated while circulating the liquid at a small flow rate so that the residual bubbles are released and float into the upper space through the communication port 31. The priming operation in this way is facilitated. In some cases, a large quantity of gas may be introduced erroneously into the vessel 21. In such case, the gas will produce eddy currents of bubbles in the central region above the filtration member 24. In order to prevent such eddy currents of bubbles from entering the lower space and reaching the liquid outlet port 26, the apparatus 20 of the second embodiment may be provided with an eddy-current blocking plate 32 above the filtration member, as indicated by the two-dot-and-dash line. The eddy-current blocking plate 32 is preferably inclined slightly so as to prevent stagnation of bubbles which may otherwise occur at the lower side of the eddy-current blocking plate.

The filtration member 24 of the apparatus 20 may accommodate a pillar 33 as shown in Figure 5. The pillar 33 conveniently reduces the volume of the lower space 23 formed at the lower side of the filtration member 24 thereby decreasing the quantity of liquid required for the priming of the apparatus 20.

Figure 6 shows a practical example of the apparatus of the invention, intended for use in the separation of bubbles from blood. This apparatus, generally denoted by a numeral 40, has a vessel 41 provided with a liquid inlet port 42, liquid outlet port 43 and a gas outlet port 44. The portion of the vessel 41 defining the liquid inlet section has an increased diameter so as to afford a greater volume to the upper space where the bubbles are separated and so as not to produce any impediment to the upward flow of the bubbles. On the other hand, the diameter of the lower portion of the vessel 41 is minimized because the size of this portion does not materially affect the bubble removing performance.

Figure 7 is a front elevational view illustrating the details of the apparatus shown in Figure 6. Figure 8 is a sectional view taken along the line X—X in Figure 7. As will be seen from these drawings, the liquid inlet port 42 of the apparatus 40 opens in the wall 45 of the cylindrical vessel in a tangential direction thereto, at a level near the upper end of the filtration member 24. Therefore, the blood flowing into the upper space 22 through the liquid inlet 42 forms a vortex flow as indicated by the arrows in Figure 10. Although not shown, it will be clear to those skilled in the art that the apparatus shown in Figure 5 has liquid inlets similar to that shown in Figures 7 and 8.

Table 1 shows the sizes of major parts of the apparatus 20 of the invention shown in Figure 5, as well as the quantities of the priming liquid and the values of pressure loss, in comparison with those of the conventional apparatus 1 shown in Figure 1. From this table, it will be understood that the quantity of the priming liquid and the pressure loss are much decreased in the apparatus 20 of the invention, as compared with those of the conventional apparatus 1.

TABLE 1

	Type of apparatus 1	20
D (cm)	8	4.5
H (cm)	3.5	7.5
d (cm)	—	4.5
h (cm)	—	6.5
priming volume (ml)	175	120
pressure loss (mmHg)	45 (60 mbar)	30 (40 mbar)

(Value of pressure loss measured with water at 25°C at flow rate of 6 filter per min.)

This apparatus 20 or 40 are used, for example, in an artificial lung system as shown in Figure 4. In this case, the apparatus 20, 40 is connected at a location downstream of an artificial lung 101 and upstream of the human body 102 as viewed in the direction of flow of the blood, but very close to the human body 102. The heart and lung machine has a blood reservoir 103, pump 104 and a heat exchanger 105. The apparatus 20, 40 is primed with physiological saline, lactic Ringer's solution or a similar liquid, before it is charged with the blood to be treated. Then, the blood to be treated is introduced through the liquid inlet port 25 into the upper space 22 to fill up the latter and flows therein in the form of a vortex flow. The vortex flow of the blood in the upper space 22 of the vessel 21 is progressively moved from the peripheral portion to the central portion of the upper space 22. In the outer peripheral zone of the vortex flow of the blood where the velocity of flow of the blood is comparatively high, the bubbles and the blood, having different specific gravities, are separated from each other by the action of a large centrifugal force. The blood and the bubbles separated centrifugally are progressively moved to the radially inner zone while the velocity is markedly reduced. In this zone, a high degree of buoyancy is imparted to the bubbles so that they float and move upwardly, while the blood alone is allowed to enter the lower space 23 through the

mesh of the filtration member. On the other hand, these bubbles of the gas are moved upwardly into the uppermost region of the upper space 22 where the gas of these bubbles accumulates. When a predetermined quantity of air has accumulated in this uppermost region, the valve 28 is opened so as to relieve the gas from the gas outlet port 27. The valve 28 may be a two-way or three-way cock. Alternatively, the gas outlet port 27 is always kept open to let a small quantity of blood together with the gas pass to equipment such as a cardiotomy reservoir.

As will be understood from the foregoing description, in the described embodiment of the apparatus 20 for removing the bubbles, the blood in which bubbles are suspended is made to form a vortex flow in the vessel 21 so that the bubbles are efficiently separated from the blood by both the centrifugal force in the outer peripheral zone and the axially upward floating force in the central zone. Therefore, the blood in the portion of the upper space 22 around the filtration member 24 is rid of bubbles. With this arrangement, therefore, it is possible to effectively remove fine bubbles of diameters less than 0.1 mm, even when the filtration member 24 is made of a porous material having a comparatively large pore size ranging between 50 and 260 micrometers, unlike the conventional arrangement in which bubbles are trapped by filtration member. In addition, the described arrangement ensures a high degree of safety and reliability with this apparatus. Furthermore, the use of a filtration member having pore sizes around 260 micrometers makes it possible to reduce the pressure loss across the filtration member and effectively prevent breakage of structures such as blood platelets, blood cells and so forth through the liquid discharge port 16, thereby affording a sufficiently long time for the separation of bubbles. In addition, the entirety of the filtration area of the filtration member 14 can be used equally effectively.

During the operation of the apparatus 20, a large quantity of air may be introduced accidentally, which air stagnates in the center of the vortex flow forming eddy currents of air. Such eddy currents of air, however, are prevented from entering the lower space 13 by the presence of the closure plate affixed to the upper end of the filtration member 14, thereby unfailingly preventing the discharge of the bubbles through the liquid outlet port 16.

With the inventive arrangement, it is possible to satisfactorily remove bubbles from a liquid such as blood, while reducing the pressure loss of the liquid across the filtration member and reducing the quantity of the liquid required for priming.

According to one embodiment of the invention in which the filtration member is made of hydrophilic material or is treated to become hydrophilic, it is possible to prevent bubbles from becoming attached to the filtration member to eliminate any dead area on the same.

Furthermore, due to employing a conical filtration member, an ample volume is preserved for the upper space between the vessel wall and the filtration member, thereby allowing efficient separation of the bubbles and smooth upward flow of the separated bubbles without any impediment. Consequently, the outside diameter of the vessel can be decreased to reduce the quantity of the liquid necessary for priming.

In another embodiment of the invention, a communication port is formed in the upper end of the filtration member to provide communication between the liquid inlet space and the liquid outlet space. Through this communication port, any residual bubbles in the liquid outlet space or attached to the lower surface of the filtration member are released into the liquid inlet space so that the priming operation is considerably facilitated.

Furthermore, an eddy-current blocking plate is provided on or above the top of the filtration member. This arrangement effectively prevents eddy currents of bubbles formed when a large quantity of gas is accidentally introduced into the vessel from reaching the liquid outlet port through the liquid outlet space below the filtration member.

Claims

1. An apparatus for removing bubbles from a liquid, comprising:

a generally cylindrical vessel (21, 41);

a filtration member (24) disposed in said vessel (21, 41) and dividing the space in said vessel into a liquid inlet space (22) and a liquid outlet space (23);

a liquid inlet port (25) formed in a wall of said vessel (21, 41) in communication with said liquid inlet space (22) and adapted to introduce a liquid into said liquid inlet space (22) in the form of a vortex flow around the axis of said vessel (21, 41);

a liquid outlet port (26) formed in the wall of said vessel (21, 41) in communication with said liquid outlet space (23) and adapted to allow the treated liquid passed through said filtration member (24) to be discharged therethrough;

and a gas outlet port (27) formed in the wall of said vessel (21, 41) in communication with an uppermost region of said liquid inlet space (22) and adapted to allow the gas of the separated bubbles to be discharged therethrough;

characterized in that said filtration member (24) is of a substantially conical shape and disposed in said vessel (21, 41) coaxially therewith, an upper apex end of said filtration member (24) being positioned at substantially the level of said liquid inlet port (25), and the filtration area of said filtration member (24) being reduced in the vicinity of its upper end and increasing in the axial direction toward the bottom end of said filtration member (24) in accordance with its conical configuration.

2. An apparatus according to claim 1, wherein said filtration member (24) is made of a porous material having a pore size ranging between 50 and 260 micrometers.

3. An apparatus according to claim 1, wherein said filtration member (24) is made of a hydrophilic material.

4. An apparatus according to claim 1, wherein said filtration member (24) is made of a porous material treated beforehand to become hydrophilic.

5. An apparatus according to claim 1, wherein a pillar (33) is provided in the conically shaped filtration member (24) for reducing the liquid volume thereof.

6. An apparatus according to claim 1, wherein said filtration member (24) of substantially conical shape is provided at its upper end with a communication port (31) which provides communication between said fluid inlet space (22) and said fluid outlet space (23).

7. An apparatus according to claim 1, wherein said filtration member (24) of substantially conical shape is provided over the upper apex end thereof with an eddy-current blocking plate which prevents eddy currents of bubbles formed thereon from entering said liquid outlet space (23).

Patentansprüche

1. Gerät zur Entfernung von Gasblasen aus einer Flüssigkeit, umfassend

ein im wesentlichen zylindrisches Gefäß (21, 41),

ein im Gefäß (21, 41) angeordnetes Filtrier- oder Filterelement (24), das den Innenraum des Gefäßes in einen Flüssigkeitseinlaßraum (22) und einen Flüssigkeitsauslaßraum (23) unterteilt,

eine in einer Wand des Gefäßes (21, 41) ausgebildete, mit dem Flüssigkeitseinlaßraum (22) kommunizierende Flüssigkeitseinlaßöffnung (25) zum Einleiten einer Flüssigkeit in den Flüssigkeitseinlaßraum (22) in Form einer Wirbelströmung um die Achse des Gefäßes (21, 41) herum,

eine in der Wand des Gefäßes (21, 41) ausgebildete, mit dem Flüssigkeitsauslaßraum (23) kommunizierende Flüssigkeitsauslaßöffnung (26) zur Ermöglichung eines Austrags bzw. einer Abführung der behandelten Flüssigkeit, die das Filterelement (24) passiert hat, über diese Auslaßöffnung,

und eine in der Wand des Gefäßes (21, 41) ausgebildete, mit einem obersten Bereich des Flüssigkeitseinlaßraums (22) kommunizierende Gasauslaßöffnung (27) zur Ermöglichung eines Austritts des Gases der entfernten (bzw. abgetrennten) Gasblasen über diese Auslaßöffnung,

dadurch gekennzeichnet, daß das Filterelement (24) eine im wesentlichen konische Form aufweist und im Gefäß (21, 41) koaxial dazu angeordnet ist, ein oberes Spitzen- oder Scheitelende des Filterelements (24) im wesentlichen in der Höhe der Flüssigkeitseinlaßöffnung (25) angeordnet ist und die Filtrier- oder Filterfläche des Filterelements (24) im Bereich seines oberen Endes verkleinert ist und sich in Axialrichtung zum Bodenende des Filterelements (24) hin entsprechend dessen konischer Gestalt vergrößert.

2. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das Filterelement (24) aus einem porösen Material einer Porengröße im Bereich zwischen 50 µm und 260 µm geformt ist.

3. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das Filterelement (24) aus einem hydrophilen Material geformt ist.

4. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das Filterelement (24) aus eine porösen Material geformt ist, das im voraus behandelt worden ist, um es hydrophil zu machen.

5. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß im konisch geformten Filterelement (24) eine Säule (33) zur Verkleinerung des Flüssigkeitsvolumens des Filterelements vorgesehen ist.

6. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das Filterelement (24) einer im wesentlichen konischen Form an seinem oberen Ende mit einer Verbindungsöffnung (31) versehen ist, die eine Verbindung zwischen dem Flüssigkeitseinlaßraum (22) und dem Flüssigkeitsauslaßraum (23) herstellt.

7. Gerät nach Anspruch 1, dadurch gekennzeichnet, daß das Filterelement (24) einer im wesentlichen konischen Form über seinem oberen Spitzen- oder Scheitelende mit einer Wirbelströmung-Blockierplatte versehen ist, die daran erzeugte Wirbelströmungen von Gasblasen an einem Eintritt in den Flüssigkeitsauslaßraum (23) hindert.

Revendications

1. Appareil pour éliminer les bulles d'un liquide, comprenant:

un récipient généralement cylindrique (21, 41);

un élément de filtration (24) placé dans ledit récipient (21, 41) et divisant l'espace dans ledit récipient en un espace d'entrée de liquide (22) et un espace de sortie de liquide (23);

un orifice d'entrée de liquide (25) formé dans une paroi dudit récipient (21, 41) en communication avec ledit espace d'entrée de liquide (22) et adapté pour introduire un liquide dans ledit espace d'entrée de liquide (22) sous la forme d'un écoulement tourbillonnaire autour de l'axe dudit récipient (21, 41);

un orifice de sortie de liquide (26) formé dans la paroi dudit récipient (21, 41) en communication avec ledit espace de sortie de liquide (23) et adapté pour permettre au liquide traité ayant traversé ledit élément de filtration (24) d'être évacué par celui-ci;

et un orifice de sortie de gaz (27) formé dans la paroi dudit récipient (21, 41) en communication avec un région la plus haute dudit espace d'entrée de liquide (2) et adapté pour permettre au gaz des bulles séparées d'être évacué par celui-ci;

caractérisé en ce que ledit élément de filtration (24) a une forme sensiblement conique et est placé dans ledit récipient (21, 41) de façon coaxiale à celui-ci, une extrémité de pointe supérieure dudit élément de filtration (24) étant placée sensiblement au niveau dudit orifice d'entrée de

liquide (25), et la surface de filtration dudit élément de filtration (24) étant réduite à proximité de son extrémité supérieure et augmentant dans la direction axiale vers l'extrémité inférieure dudit élément de filtration (24) selon sa configuration conique.

2. Appareil selon la revendication 1, dans lequel ledit élément de filtration (24) est fait d'une matière poreuse ayant une taille de pore comprise entre 50 et 260 micromètres.

3. Appareil selon la revendication 1, dans lequel ledit élément de filtration (24) est fait d'une matière hydrophile.

4. Appareil selon la revendication 1, dans lequel ledit élément de filtration (24) est fait d'une matière poreuse traitée au préalable pour devenir hydrophile.

5. Appareil selon la revendication 1, dans lequel une colonne (33) est placée dans l'élément de filtration de forme conique (24) pour réduire le volume de liquide de celui-ci.

6. Appareil selon la revendication 1, dans lequel ledit élément de filtration (24) de forme sensiblement conique est équipé à son extrémité supérieure d'un orifice de communication (31) qui assure une communication entre ledit espace d'entrée de fluide (22) et ledit espace de sortie de fluide (23).

7. Appareil selon la revendication 1, dans lequel ledit élément de filtration (24) de forme sensiblement conique est équipé sur son extrémité de pointe supérieure d'une plaque de blocage de courant parasite qui empêche les courants parasites des bulles formés dessus d'entrer dans ledit espace de sortie de liquide (23).

FIG. 1

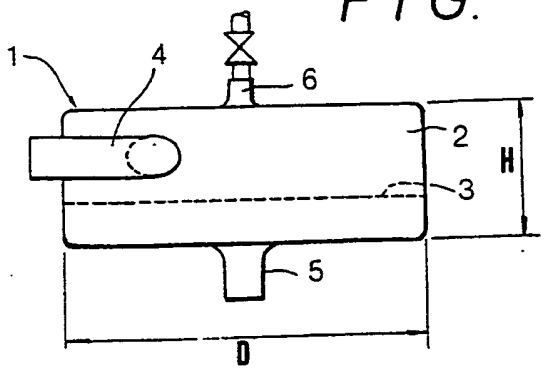


FIG. 2

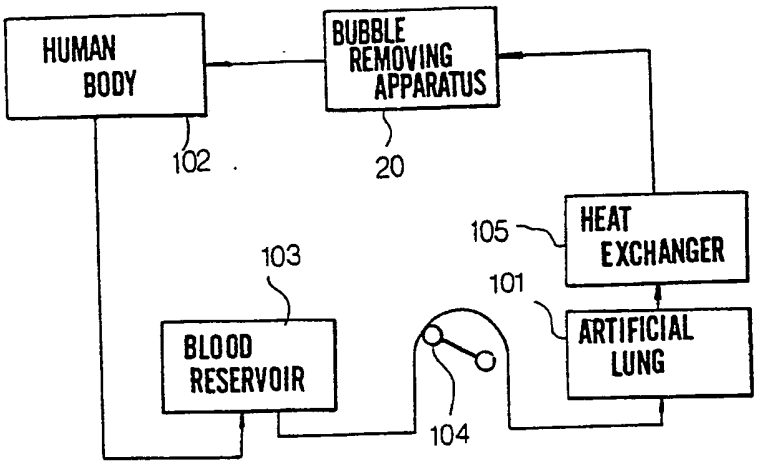
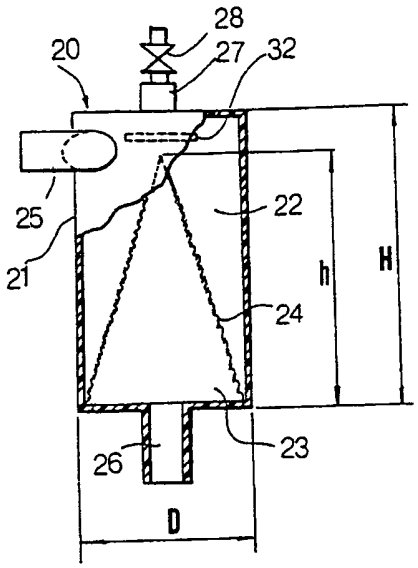

HUMAN BODY
BUBBLE REMOVING APPARATUS
102
20
105
HEAT EXCHANGER
103
101
BLOOD RESERVOIR
ARTIFICIAL LUNG
104

FIG. 3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23
D

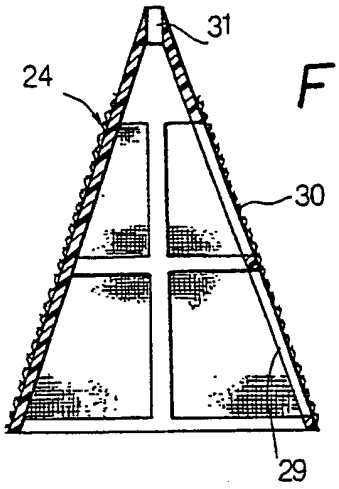

FIG. 4

FIG. 5

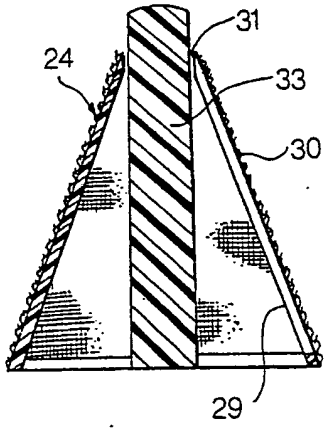

FIG. 6

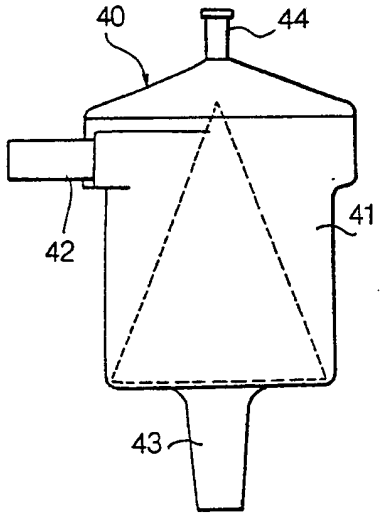

FIG. 7

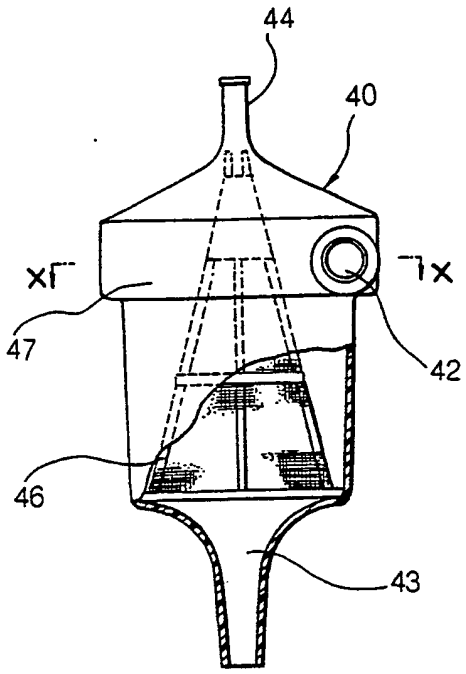

FIG. 8